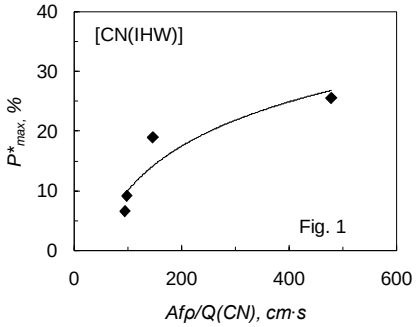
POSITIVE POLARIZATION AND DUST-TO-GAS RATIO IN COMETS. L. F. Golubeva, D. I. Shestopalov, Shemakha Astrophysical Observatory, Shemakha AZ-3243 Azerbaijan, (shestopalov_d@mail.ru), (lara_golubeva@mail.ru).

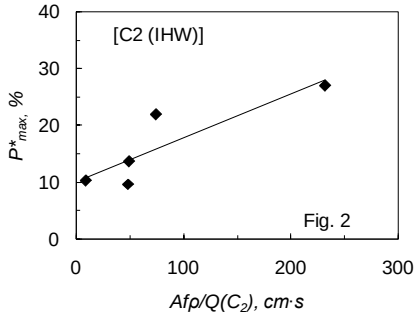
Two main viewpoints on the polarimetric classification of comets are currently discussing in comet literature. According to one of them, the low- and high-P_{max} comets are predominantly the dust-rich and gas-rich ones if to characterize a dust-to-gas ratio in their envelopes by an equivalent width W_{4845} at λ=4845 Å [1, 2, 3]. In turn, the authors [4] analyzed the properties of W_{4845} parameter and concluded that this quantity remains poorly understood, does not well characterize the dust-to-gas ratio in comets, and most likely may depend on heliocentric distance of comet. The authors [4] argue that the polarimetric curves of comets are controlled by dust constituents of their comae. They have developed a theoretical model to fit the observed polarimetric curves of comets over wide phase angle range with variation of maximum polarization degree from 7 to 30 %. It is important to ascertain, which of the approaches better corresponds to available observation data.

To estimate the production of dust in cometary envelopes, the $Af\rho$ parameter is commonly employed [5, 6]. Here A is the albedo of dust particles, f is the fraction of the aperture of measuring instrument filled by particles, and ρ is the radius of observing aperture. The $Af\rho$ parameter is independent of aperture size and suitable for quick estimating (in units of length) the dust component in comets. In spectroscopic survey of comets [6], the solar reflected continuum was converted to the $Af\rho$ in the narrow range of 6231 – 6267 Å with no emissions detected. In addition, the production rate ratios for the daughter species C_2, NH_2, CN, and dust $Af\rho$ with respect to dominant parent molecule H_2O were calculated for 50 comets [6]. Due to this, we have possibility to match the maximum polarization degree estimated in the spectral continuum near 6675 Å and in the emission bands CN (3870 Å) and C_2 (5140 Å) of some comets against the average ratio of the dust to gas, that is $Af\rho/Q(H_2O)$, $Af\rho/Q(CN)$, and $Af\rho/Q(C_2)$ respectively, obtained in terms of cm·s.

For the comets, the P^*_{max} values and their errors (about ± 2%) were previously calculated in [7] based on initial data from Database of Comet Polarimetry [8]. An asterisk denotes the maximum polarization degree found from the slope of the polarimetric function of comet in the phase angle range of 30° – 50°. The method predicts the maximum polarization degree with accuracy comparable with observation errors and especially useful for the comets with "short" polarimetric curves.

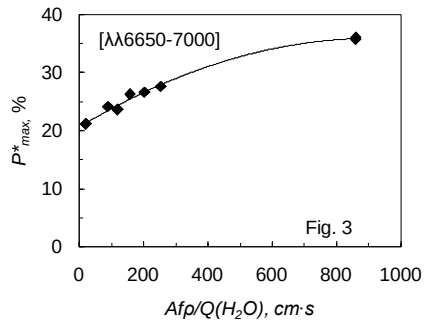
Figures 1 and 2 demonstrate the direct correlations between P^*_{max} estimated through the IHW filters centered in the emission bands and the respective dust-to-gas ratios. These P^*_{max} values is higher for those comets which less contain respective gaseous species with the respect to the dust. Figure 3 shows a similar behavior of P^*_{max} estimated in the red continuum of cometary spectra depending on the dust-to-gas ratio. As well as in the previous Figures, the higher P^*_{max} the lower concentration of the gas component, that is H_2O molecules in the given case.

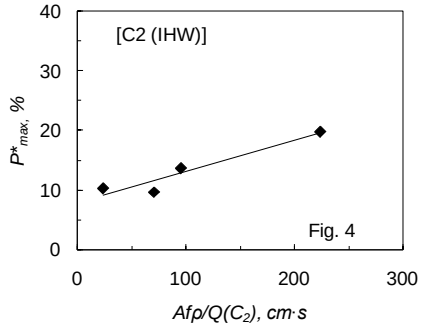


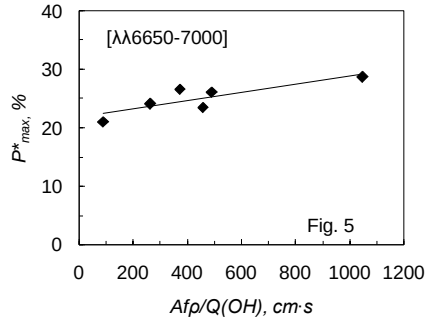


Water is known to be dominant molecule in the envelopes of comets, but the visible region of spectra is free from water features. To explain the interrelation shown in Fig. 3 it should keep in mind that the surface of cometary nuclei is thermostatically controlled by the sublimation of surface ices. The thermal model of a cometary nucleus consisting of dust mixed with water ice and admixtures has been considered in [9]. In particular, admixtures thermodynamically similar to water and uniformly distributed in the thickness of cometary material evaporate at the rate of water ice sublimation. Observational evidence of this approach is the interrelationships between the production rates of C_2,

C_3, CH, NH, NH_2 OH, CN and H_2O [6, 10, 11, 12]. Pursuant to [13, 14], it may be reasonably good guess that the species mentioned above as well as the unknown constituents produce a great number of emission lines of different intensity that can be detected in comet spectra of high resolution. Some of those lines could contaminate dust continuum in various spectral ranges, making a continuum level dependent on the dust-to-gas ratio.







To check the revealed correlation for validity, we also employed the $Af\rho/Q$(species) ratios in the same units from the narrowband photometric survey of comets [15] and reached the similar result shown on Figs. 4 and 5. So we can conclude as follows:

(i) such base characteristic of cometary comae as the dust-to-gas ratio makes detectable contribution to the variation of positive polarization degree in comet;

(ii) the ratio can be one of the factors that determines the division of comets into groups with high and low polarization;

(iii) the polarimetric effect of resonant fluorescence of gas molecules should be completely eliminated from the phase-dependent polarization curve of comet in order to correctly interpret the physical properties of cometary dust.

References:

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